

**TABLE 21.18-A
SOIL LATERAL LOAD**

Description of Backfill Material^e	Unified Soil Classification	Design Lateral Soil Load^a PSF per Foot of Depth
Well-graded, clean gravels; gravel-sand mixes	GW	30 ^c
Poorly graded clean gravels; gravel-sand mixes	GP	30 ^c
Silty gravels, poorly graded gravel-sand mixes	GM	40 ^c
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45 ^c
Well-graded, clean sands; gravelly sand mixes	SW	30 ^c
Poorly graded clean sands; sand-gravel mixes	SP	30 ^c
Silty sands, poorly graded sand-silt mixes	SM	45 ^c
Sand-silt clay mix with plastic fines	SM-SC	45 ^d
Clayey sands, poorly graded sand-clay mixes	SC	60 ^d
Inorganic silts and clayey silts	ML	45 ^d
Mixture of inorganic silt and clay	ML-CL	60 ^d
Inorganic clays of low to medium plasticity	CL	60 ^d
Organic silts and silt clays, low plasticity	OL	^b
Inorganic clayey silts, elastic silts	MH	60 ^d
Inorganic clays of high plasticity	CH	^b
Organic clays and silty clays	OH	^b

a. Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.

b. Unsuitable as backfill material.

c. For relatively rigid walls, as when braced by floors, the design lateral soil load shall be increased for sand and gravel type soils to 60 psf per foot of depth. Basement walls extending not more than 8 feet below grade and supporting flexible floor systems are not considered relatively rigid walls.

d. For relatively rigid walls, as when braced by floors, the design lateral load shall be increased for silt and clay type soils to 100 psf per foot of depth. Basement walls extending not more than 8 feet below grade and supporting flexible floor systems are not considered relatively rigid walls.

e. Soil classes are in accordance with the Unified Soil Classification System, ASTM D2487, and design lateral loads are for moist soil conditions without hydrostatic pressure.

Foundation Wall Lateral Support

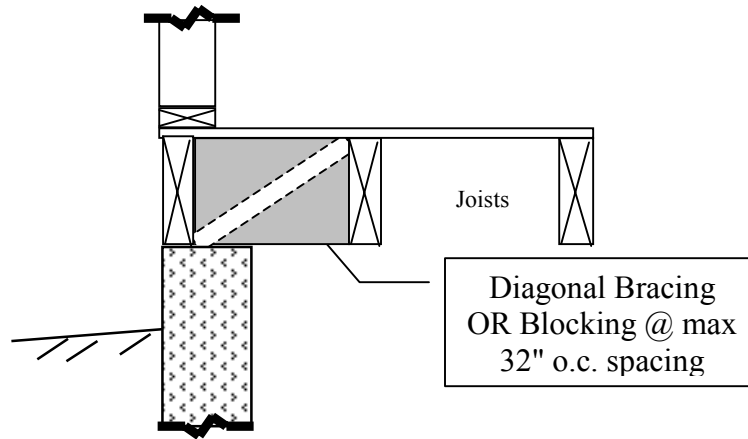
Question: Why is lateral restraint required for foundation walls?

Answer: All of the UDC concrete and masonry foundation wall tables are based upon the assumption of lateral support at both the base and top of the walls.

The base of the wall typically is restrained by the floor slab or the footing by a keyed joint or rebar. The top edge of the foundation wall may be restrained by the first floor through mechanical fastening or ledger blocking. (Ledger

blocking alone will not satisfy the dwelling anchorage requirement of s. 21.02(1)).

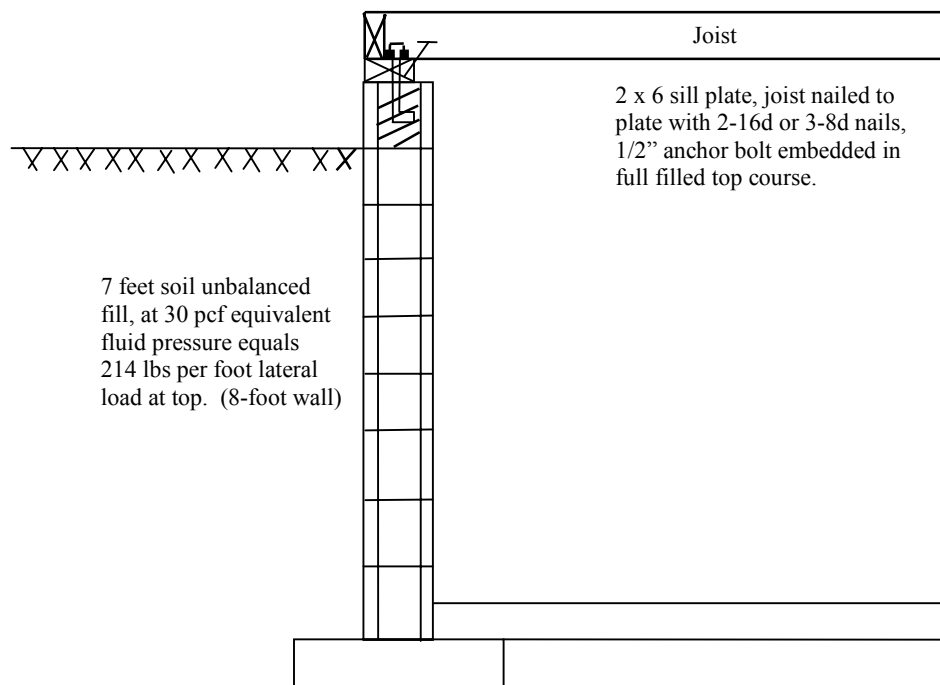
Section 21.18(1)(d)2.a. (1m) requires that lateral restraint shall be continuous from the wall to the plate to the restraining floor system. This may require that solid bridging or blocking be installed between the rim joist and adjacent floor joist that run parallel to the foundation wall to transfer the loads on the wall.



Another method would be to furr the inside of the foundation wall with 2 x 4s or an engineered system secured to the joists and bearing against the foundation wall or foundation wall footing.

A special case arises where the fill around a foundation is uneven, as in a walkout basement. In this case the soil pressure on either side of the house is not balanced, thereby possibly causing lateral racking movement of the foundation and floor system. To resist this, additional lateral support by rigid (plywood sheathed) interior cross walls or by pilasters may be needed.

FOUNDATION LATERAL RESTRAINT



In addition to bolts, other means such as straps or engineered connections may be used to provide lateral restraint to the top of the foundation wall.

(2) CONCRETE FOUNDATION WALLS. (a) Except as provided in par. (b), unless designed through structural analysis, the minimum thickness of concrete foundation walls shall be determined from Table 21.18-B, but in no case shall the thickness of the foundation wall be less than the thickness of the wall it supports.

(b) A 6-inch nominal wall thickness may be used provided the fill on one side of the wall is within 12 inches vertically of the fill on the other side of the wall.

TABLE 21.18-B

CONCRETE WALL THICKNESSES

Type of Concrete	Nominal Thickness (inches)	Maximum Height of Unbalanced Fill ¹ for Material of Wall Being Supported (Wood frame - feet)
3000 psi		
Unreinforced concrete	8	8
	10	9
	12 ²	10
	14	11.5

¹ Unbalanced fill is the difference in elevation between the outside grade and the basement floor.

² The maximum height of unbalanced fill for a 12-inch thick plain concrete wall may be increased to 12 feet provided the wall is constructed of concrete with a minimum compressive value of 6,000 psi at 28 days.

Concrete Foundation Walls

Question: *Is a 6-inch thick concrete foundation wall acceptable for supporting a 2 x 6 frame wall? The thickness of the frame wall with sheathing, siding, and drywall will exceed the 6-inch foundation wall thickness.*

Answer: *“In no case shall the thickness of the foundation wall be less than the thickness of the wall it supports.” This requirement refers to the width of the structural members of the supported wall. In the wall in question, only the 2 x 6 framing (5.5 inches) are considered structural supporting members, therefore the proposed wall is acceptable.*

Question: *Are there situations where the department will allow unreinforced concrete supporting walls thinner than specified in Table 21.18-A?*

Answer: *Yes, the department will allow 6-inch unreinforced concrete walls to be used provided the fill is within 12 inches of being evenly balanced on both sides of the wall. The top of any concrete slab and the finish grade is used to determine this measurement, such as in an attached garage situation or slab-on-grade dwelling.*

Table 21.18-A was developed to assist in determining the maximum height of unbalanced fill that may be placed against a basement wall. The Uniform Dwelling Code has never dealt directly with the issue of wall thickness where the fill is balanced on both sides. During a recent code update cycle, the entry in the table for 6-inch walls was deleted because the American Concrete Institute no longer allows unreinforced foundation walls or exterior basement walls less than 7.5 inches thick. However, section 7.1.6.2 of ACI 318.1-1989 allows bearing walls to be a minimum of 5.5 inches thick. With the fill balanced to within the 12-inch condition imposed above, the wall will be considered a bearing wall rather than a foundation or exterior basement wall. A 12-inch variation will still allow flexibility in grading without necessarily mandating the preservation of wall structural members.

Question: *What strength of concrete is a five-bag mix?*

Answer: *The strength of concrete is dependent upon a number of factors including the cement-water ratio involved in the mix. A five-bag mix means that 470 lbs. of cement is used per cubic yard of concrete. Without knowing how much water is also used per cubic yard of concrete, the actual design strength of the concrete cannot be determined. Concrete suppliers should have their design mixes tested prior to field use per the American Concrete Institute (ACI) specifications. (See following section.)*

Concrete Foundation Walls (Concrete Quality)

Compressive Strength of Concrete

The average strength of concrete produced must always exceed the specified value of concrete strength (f'_c) that was used in the structural design phase. This is based on probabilistic concepts, and is intended to ensure that adequate strength will be developed in the structure.

Acceptable Practice for Concrete Design

The specified strength of concrete for foundations and footings in one- and two-family dwellings shall be at least 2,500 PSI per s. 4.2 of ACI 318.1-89, Plain Concrete Code. The height of 3,000 psi concrete foundation walls shall be governed by Table 21.18-A or alternately, for greater or lesser concrete strengths, through engineered design. Table 21.18-A assumes the wall has lateral support at both top and bottom.

Proportioning on the Basis of Field Experience

For establishing concrete proportions, emphasis is placed on the use of laboratory trial batches or field experience as the basis for selecting the required water/cement ratio. If an applicable standard deviation for strength tests of the concrete is known, this establishes the target strength level from which the concrete must be proportioned. Otherwise, the proportions must be selected to produce an excess of target strength sufficient to allow for a high degree of variability in the strength tests.

Where the concrete production facility has a record based on at least 30 consecutive strength tests representing similar materials and conditions to those expected, the strength used as the basis for selecting proportions shall exceed the required specified strength of concrete (f'_c) by at least:

TABLE A. REQUIRED OVERDESIGN

Standard Deviation (psi)	Required Average (psi)
Under 300	$f'_c + 400$
300 - 400	$f'_c + 550$
400 - 500	$f'_c + 700$
500 - 600	$f'_c + 900$
Over 600	$f'_c + 1200$
Unknown	$f'_c + 1200$

The indicated average strength levels are intended to reduce the probability of concrete strength being questioned on any of the following usual bases: (1) too many tests below specified f'_c ; (2) strength averaging below specified f' for an appreciable period (three

consecutive tests); or (3) an individual test being disturbingly low (more than 500 psi below specified f'_c).

Proportioning on Basis of Acceptable Practice

If test data is not available, the following water/cement weight ratio may be used to determine acceptable concrete strength.

3000 PSI concrete use .58 water/cement ratio

The following tables give guidelines for proportioning a mix of 1 cubic yard to develop acceptable strength levels. Recommended slump for footings, foundation and slabs is between 1 and 3 inches.

TABLE C APPROXIMATE MIX FOR SLUMP OF 1-2 INCHES

<u>Size</u> <u>Aggregate</u>	<u>Water</u> <u>Lbs.</u>	<u>Gallons</u>	<u>LB. of</u> <u>Cement</u>	<u>3000 PSI</u> <u>94#</u> <u>Bags</u>	<u>Percent*</u> <u>Volume</u> <u>of Coarse</u> <u>Aggregate</u>
1/2"	335	40	578	6.2	50-60
1"	300	36	517	5.5	64-72
1 1/2"	275	33	474	5.0	68-76
2"	260	31	448	4.8	71-79

TABLE D APPROXIMATE MIX FOR SLUMP OF 3-4 INCHES

<u>Size</u> <u>Aggregate</u>	<u>Water</u> <u>Lbs.</u>	<u>Gallons</u>	<u>LB. of</u> <u>Cement</u>	<u>3000 PSI</u> <u>94#</u> <u>Bags</u>	<u>Percent*</u> <u>Volume</u> <u>of Coarse</u> <u>Aggregate</u>
1/2"	365	44	629	6.7	50-60
1"	325	39	560	6.0	64-72
1 1/2"	300	36	517	5.5	68-76
2"	285	34	508	5.4	71-79

**Percent of coarse aggregate will vary with different fineness moduli of sand.*

(3) MASONRY FOUNDATION WALLS. (a) Dampproofing. Masonry foundation walls shall be dampproofed by applying to the exterior surface from footing to finished grade, a continuous coating of one of the following:

1. Portland cement and sand coat mortar, at least 3/8 inch thick.
2. Type M or S mortar, at least 3/8 inch thick.
3. Structural surface bonding material, at least 1/4 inch thick.
4. Equivalent dampproofing material, applied in accordance with the manufacturer's instructions and acceptable to the department.

(b) Structural requirements. Unless designed through structural analysis, the masonry foundation walls shall be constructed in accordance with ACI 530.1 and the following requirements:

1. The minimum thickness of unreinforced masonry foundation walls shall be determined by Table 21.18-C, but in no case shall the thickness be less than the thickness of the wall it supports.

2. Reinforced masonry walls shall be reinforced in accordance with the requirements of Tables 21.18-D, 21.18-E or 21.18-F. Vertical reinforcement shall be provided on each side of any opening and at intervals indicated in the appropriate table.

3. Vertical reinforcement shall have a minimum yield strength of 60,000 psi.

4. Solid-grouted hollow units or cores containing vertical reinforcement shall be filled with masonry grout that complies with ASTM C 476.

5. In lieu of the reinforcement provisions of Tables 21.18-D, 21.18-E and 21.18-F, alternative reinforcing bar size and spacing having an equivalent cross-sectional area or reinforcement per linear foot of wall is permitted, provided the spacing of the reinforcement does not exceed 72 inches and reinforcing bar size does not exceed No. 11.

6. The depth below grade, wall height and reinforcement spacing may exceed the maximum values indicated in Tables 21.18-D, 21.18-E and 21.18-F only if the design is based on structural analysis.

Dampproofing

Question: *Could you clarify the UDC requirements for waterproofing of poured concrete foundation walls?*

Answer: *This section only specifically requires waterproofing of masonry foundation walls. Section Comm 20.24 (2) adopts American Concrete Institute's Standards ACI 318-83 and ACI 318.1-83 for reinforced and plain concrete. Neither of these standards mention waterproofing requirements. In summary, there are no requirements for waterproofing of poured concrete walls in new one- and two-family dwelling construction.*

Question: *The footings and concrete block foundation of a house will be located in a clay-type soil with the foundation wall being insulated on the exterior from the footing to the top. Does the foundation wall have to be dampproofed before the insulation is applied?*

Answer: *Yes, this section requires dampproofing of masonry foundation walls of basements in clay-type soils with a continuous coat of at least 3/8-inch thick portland cement and sand coat mortar, a type M mortar troweled smooth, or 1/4-inch bonding materials applied to the exterior surfaces. The exterior applied insulation may then be installed.*

Table 21.18-C
PLAIN MASONRY FOUNDATION WALLS ^d

Maximum Wall Height (ft - in)	Depth of unbalanced backfill height (ft)	Minimum nominal wall thickness (inches)		
		Soil classes and lateral soil load ^a (psf per foot of depth)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC and ML soils 45	SC, MH, ML-CL and inorganic CL soils 60
7 - 0 7 - 8	4 (or less)	8	8	8
	5	8	10	10
	6	10	12	10 (solid ^b)
	7	12	10 (solid ^b)	12 (solid ^b)
8 - 4	4 (or less)	8	8	8
	5	8	10	12
	6	10	12	12 (solid ^b)
	7	12	12 (solid ^b)	Note c
9 - 1	8	10 (solid ^b)	12 (solid ^b)	Note c
	4 (or less)	8	8	8
	5	8	10	12
	6	12	12	12 (solid ^b)
	7	12 (solid ^b)	12 (solid ^b)	Note c
	8	12 (solid ^b)	Note c	Note c
	9	Note c	Note c	Note c

a. For design lateral soils and descriptions of soil classes, see s. Comm 21.18(1)(d). Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Solid grouted hollow units.

c. An analysis in compliance with ACI 530 or reinforcement in accordance with Table 21.18-D, 21.18-E or 21.18-F is required.

d. Mortar shall be Type M or S and masonry shall be laid in running bond.

TABLE 21.18-D^{b,c,d}
8, 10 OR 12 IN. REINFORCED MASONRY FOUNDATION WALLS WHERE $d \geq 5$ in.^e

Maximum Wall Height (ft - in)	Height of unbalanced backfill (ft)	Vertical reinforcement		
		Soil classes and lateral soil load ^a (psf per foot of depth)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC and ML soils 45	SC, MH, ML-CL and inorganic CL soils 60
7 - 0 7 - 8	4 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 40" o.c.
	6	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 40" o.c.
	7	#4 at 40" o.c.	#5 at 40" o.c.	#6 at 48" o.c.
8 - 4	4 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 40" o.c.
	6	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 40" o.c.
	7	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 40" o.c.
9 - 1	8	#5 at 40" o.c.	#6 at 40" o.c.	#7 at 40" o.c.
	4 (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6	#4 at 48" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	7	#5 at 48" o.c.	#6 at 48" o.c.	#7 at 48" o.c.
	8	#5 at 40" o.c.	#7 at 48" o.c.	#8 at 48" o.c.
	9	#6 at 40" o.c.	#8 at 48" o.c.	#8 at 32" o.c.

a. For design lateral soil loads, see s. Comm 21.18(1)(d). Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in s. Comm 21.18 (3) (b).

c. For alternative reinforcement, see s. Comm 21.18 (3) (b).

d. Mortar shall be Type M or S and masonry shall be laid in running bond.

e. The specified location of the reinforcement shall equal or exceed the effective depth distance, d , measured from the face of the soil side of the wall to the center of vertical reinforcement.

TABLE 21.18-E^{b,c,d}
10 OR 12 IN. REINFORCED MASONRY FOUNDATION WALLS WHERE $d \geq 6.75$ in.^e

REINFORCED MASONRY				
Maximum Wall Height (ft – in)	Height of unbalanced backfill (ft)	Vertical reinforcement		
		Soil classes and lateral soil load^a (psf per foot below natural grade)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC and ML soils 45	SC, MH, ML-CL and inorganic CL soils 60
7 – 0 7 – 8	4 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	6	#4 at 56" o.c.	#4 at 48" o.c.	#4 at 40" o.c.
	7	#4 at 56" o.c.	#5 at 56" o.c.	#5 at 40" o.c.
8 – 4	4 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 48" o.c.
	6	#4 at 56" o.c.	#4 at 48" o.c.	#5 at 56" o.c.
	7	#4 at 48" o.c.	#4 at 32" o.c.	#6 at 56" o.c.
9 – 1	8	#5 at 56" o.c.	#5 at 40" o.c.	#7 at 56" o.c.
	4 (or less)	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 56" o.c.
	5	#4 at 56" o.c.	#4 at 56" o.c.	#4 at 48" o.c.
	6	#4 at 56" o.c.	#4 at 40" o.c.	#4 at 32" o.c.
	7	#4 at 40" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	8	#4 at 32" o.c.	#6 at 48" o.c.	#4 at 16" o.c.
	9	#5 at 40" o.c.	#6 at 40" o.c.	#7 at 40" o.c.

a. For design lateral soil loads, see s. Comm 21.18 (1) (d). Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in s. Comm 21.18 (3) (b).

c. For alternative reinforcement, see s. Comm 21.18 (3) (b).

d. Mortar shall be Type M or S and masonry shall be laid in running bond.

e. The specified location of the reinforcement shall equal or exceed the effective depth distance, d , measured from the face of the soil side of the wall to the center of vertical reinforcement.

TABLE 21.18-F^{b,c,d}
12 IN. REINFORCED MASONRY FOUNDATION WALLS WHERE $d \geq 8.75$ in.^e

REINFORCED MASONRY				
Maximum Wall Height (ft - in)	Height of unbalanced backfill (ft)	Vertical reinforcement		
		Soil classes and lateral soil load^a (psf per foot below natural grade)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC and ML soils 45	SC, MH, ML-CL and inorganic CL soils 60
7 – 0 7 – 8	4 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6	#4 at 72" o.c.	#4 at 64" o.c.	#4 at 48" o.c.
	7	#4 at 72" o.c.	#4 at 48" o.c.	#5 at 56" o.c.
8 – 4	4 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	6	#4 at 72" o.c.	#4 at 56" o.c.	#5 at 72" o.c.
	7	#4 at 64" o.c.	#5 at 64" o.c.	#4 at 32" o.c.
9 – 1	8	#4 at 48" o.c.	#4 at 32" o.c.	#5 at 40" o.c.
	4 (or less)	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 72" o.c.
	5	#4 at 72" o.c.	#4 at 72" o.c.	#4 at 64" o.c.
	6	#4 at 72" o.c.	#4 at 56" o.c.	#5 at 64" o.c.
	7	#4 at 56" o.c.	#4 at 40" o.c.	#6 at 64" o.c.
	8	#4 at 40" o.c.	#6 at 64" o.c.	#6 at 48" o.c.
	9	#5 at 56" o.c.	#7 at 72" o.c.	#6 at 40" o.c.

a. For design lateral soil loads, see s. Comm 21.18 (1) (d). Soil classes are in accordance with the Unified Soil Classification System and design lateral soil loads are for moist soil conditions without hydrostatic pressure.

b. Provisions for this table are based on construction requirements specified in s. Comm 21.18 (3) (b).

c. For alternative reinforcement, see s. Comm 21.18 (3) (b).

d. Mortar shall be Type M or S and masonry shall be laid in running bond.

e. The specified location of the reinforcement shall equal or exceed the effective depth distance, d , measured from the face of the soil side of the wall to the center of vertical reinforcement.

Masonry Foundation Walls

In addition to Tables 21.18-B, C, D, designers may use two alternative methods of designing masonry walls.

- 1. Builder may design a reinforced wall design using structural analysis per s. Comm 21.18(2) and s. Comm 21.02(3)(e) "Concrete Masonry Handbook" or other accepted engineering standard.*
- 2. Builder may design using s. Comm 53.322 of the Commercial Building Code as an engineering standard. This "Empirical Method of Design" could be used as a structural design aid per s. Comm 21.18(2).*

(4) WOOD FOUNDATIONS. Wood foundations shall be designed and constructed in accordance with "The Permanent Wood Foundation System, Basic Requirements, Technical Report No. 7," as adopted under s. Comm 20.24, Table 20.24-2 and the following exception. The thickness of the foundation wall shall be no less than the thickness of the wall it supports.

(a) Exception. Section 3.3.1. Fasteners. Fasteners shall be of silicon bronze, copper or stainless steel types 304 or 316.

Note: Additional explanatory information regarding wood foundations can be obtained in "All-Weather Wood Foundation Systems, Design, Fabrication, Installation Manual," published by the National Forest Products Association.

(b) Materials. All lumber and plywood shall be pressure treated with preservative and labeled to show conformance with AWPA C-22.

Wood Foundations

A copy of The Permanent Wood Foundation System, Basic Requirements, Technical Report No. 7 may be obtained from the:

*American Forest & Paper Association
1111 19th Street, NW
Suite 800
Washington, DC 20036
(202) 463-2700 · info@afandpa.org*

The overview which follows is meant as an introduction to the system. Inspectors and designers are urged to obtain a copy of Technical Report No. 7 before inspecting or designing wood foundations.

Part I. General Description

The Permanent Wood Foundation (PWF) system was developed cooperatively between the wood products industry and the U.S. Forest Service. The system is recognized by all national model codes.

The general framing assembly is similar to above-grade wall construction except for three features:

- 1. Framing, sheathing and footer plates are designed to resist lateral soil loads in addition to vertical loads which control most above-grade wall design.*
- 2. All material is preservative treated and fasteners are corrosion resistant.*

3. *Soil drainage and exterior waterproofing are integral to the performance of the wall system. Without these features, soil water pressures and presence could result in failure.*

Part 2. Scope

The Technical Report is developed for adoption by code-enforcing authorities. It in turn adopts national standards regarding preservative treatment, fastener, NDS, plywood specifications, etc.

Another manual entitled the "Permanent Wood Foundation System Design, Fabrication, Installation Manual" is also available from NFPA. This manual is helpful as a design tool and includes structural tables and construction details.

Part 3. Materials

As in s. Comm 21.02 (and the NDS), all lumber and plywood should be grade or span rating stamped to identify its structural properties.

Per s. Comm 21.18(3)(a), fasteners shall be of silicon bronze, copper or stainless steel materials for use in preservative treated wood installed below grade. Hot dipped zinc coated steel nails may be used in preservative treated wood installed above grade and in some below-grade locations not subject to soil contact.

Electrogalvanized nails, staples, hot dipped zinc, or other zinc coated staples are not permitted.

Framing anchors shall be of zinc coated sheet steel. Nails used to install framing anchors shall meet the above fastener requirements.

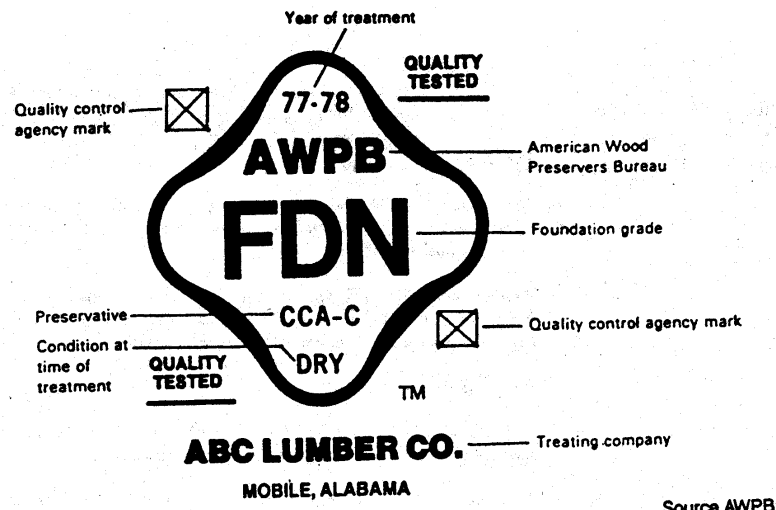
Materials used for footings or fill shall consist of gravel, coarse sand or crushed stone. Such materials should be free of organic, clayey or silty soils.

Polyethylene sheeting must be suitable for construction, industrial or agricultural applications. Typically a six-mil thickness is required.

Bonding sealants and caulking shall be suitable for the materials, temperature and moisture conditions encountered. This applies to plywood-to-plywood, plywood-to-plastic and plastic-to-plastic joints.

Part 4. Preservative Treatment

All lumber and plywood shall be preservative treated and stamped AWPB-FDN (Alternately, AWPB Standard C-22) with a preservative retention rate of .60 pounds per cubic foot of wood. The FDN suffix indicates it is allowable for wood foundation use. See following diagram.



Before such material is installed, it must be dried to a maximum 19 percent moisture content. This is important to prevent shrinkage after assembly. It also recognizes that structural strength is reduced at high moisture contents.

If AWPB-FDN lumber is cut or drilled, the cut surface must be field treated with a preservative.

Preservative treated wood is required for all foundation wall material in the ground or in contact with concrete. Some members that do not require treatment include the upper top plate, window or door headers or portions of foundation walls in walkout basements. All material within 8 inches above finished grade must be AWPB-FDN treated.

Part 5. Soil Characteristics

For the purpose of wood foundation design requirements, soils are classified into four groups:

Group 1 - Good drainage

Example: sands, gravels, silty gravels, silty sands

Group 2 - Medium drainage

Example: clayey gravels, clayey sands slightly to medium plasticity inorganic clays and silts (i.e., stiff or firm clays or silts)

Group 3 - Poor drainage

Example: highly plastic clays, very fine sands or silts

Group 4 - Unsatisfactory drainage

Example: organic silts and clays; peat and other organic soils

Group 4 soils are unsatisfactory for wood foundation (or other foundations per s. Comm 21.15(2)(b)) unless designed by a soils engineer.

Part 6. Environmental Control

To maintain a dry foundation wall and basement, additional drainage and waterproofing measures must be taken over and above the UDC minimums for other types of foundation walls.

A few key points to consider:

- 1. A drain tile system per s. Comm 21.17 is not necessarily required. The standard wood basement foundation design (in Group I, II or III soils) requires an "envelope" of gravel, crushed stone or sand porous fill about the foundation walls and basement floor. This envelope involves 4 inches of porous fill under the basement floor and footing plate (6 inches for Group III soils). Porous fill should also be used to backfill the excavation-basement wall trench for half the height of the excavation.*
- 2. This drainage envelope shall be served by a sump system similar to s. Comm 21.17(3) and (4). However, the porous fill envelope is designed to fill the sump without the mandatory use of a drain tile system.*
- 3. The porous fill under the foundation wall acts as the footing for the wall. As an alternative, a concrete footer may be used. If so, bleeders must be installed every 6 feet along the perimeter to ensure soil water along the foundation wall can be easily transmitted to the underslab drainage material and then into the sump.*
- 4. Waterproofing of the foundation wall is accomplished by a combination of sealing and installation of a waterproof membrane. All plywood panel joints are to be caulked. Polyethylene sheeting must be installed continuously over the height of the below-grade wall. All plastic-to-plastic and plastic-to-wood joints shall be lapped and sealed (caulked). A protective treated plywood or equivalent strip shall cover any poly sheeting exposed at grade to guard against damage caused by exposure to light or physical forces.*
- 5. Polyethylene sheeting is also required between the basement floor and the fill below.*

Part 7. Design Loads

The design loads in s. Comm 21.01 apply for determining the vertical load from the dwelling which the foundation supports.

Lateral soil loads are assumed equivalent to a 30 pound per cubic foot fluid pressure against the foundation walls. Unstable Group III soils and Group IV soils would require a soil engineer to determine lateral soil load.

Part 8. Structural Design

Structural design shall conform to the National Design Specification (NDS) as adopted by s. Comm 21.02(3). Also, plywood panels shall conform to the load tables in the "Plywood Design Specification" by APA.

The wood foundation structural design can be broken down into three aspects: the footing, foundation wall and the lateral support system.

The typical wood foundation wall footing consists of a composite wood footer plate and a gravel, stone or sand porous footing bed. The foundation wall base plate distributes vertical load to 2 x lumber footer plate which distributes load to the porous bed which then distributes the load to the soil below. All three components must be designed to support the load/pressures encountered. That is, the footer plate allowable stresses, the porous bed (sand, stone, gravel) or natural soil allowable pressures, should not be exceeded per the NDS or s. Comm 21.15(2).

The foundation wall itself differs from the typical masonry or concrete wall in that two separate components, the plywood and studs, must be designed to support their respective loadings. Plywood panels must conform to APA design tables. Wood studs (typically 2 x 6, 2 x 8) must conform to NDS design standards.

Besides lateral and axial loads, some walls shall be designed for racking loads. Racking loads act in the plane of the wall, in the direction of the wall length. Such loads may be caused by differential soil pressure (uneven backfill heights against the building) wind or earthquake. Buildings with walkout basements should be designed with adequate shear strength in the wall to resist racking loads.

Interior load bearing walls in such buildings shall be designed per s. Comm 21.25.

A lateral support system must be provided to brace the foundation walls against lateral soil and racking loads. This is done by anchoring the top of the wall to the floor system. The base of the wall is held in place by the basement floor. In crawl spaces without floors, at least 6 inches of soil must be provided against the inside of the wall to provide lateral support.

Where walls are parallel to floor joists (end walls) blocking shall be provided to transfer lateral load from the top plate/rim joist to the floor system.

Tables in the Appendix to Technical Report No. 7 provide structural design information for wall studs, sheathing and fasteners. Recommendations are also provided for shear wall design to resist racking loads.

Subchapter VI — Floors

Comm 21.19 Floor design.

Floors shall support all dead loads plus the minimum unit live loads as set forth in s. Comm 21.02. The live loads shall be applied to act vertically and uniformly to each square foot of horizontal floor area. Basements shall be provided with wood or concrete or similar type floors that comply with s. Comm 21.20 or 21.205.

Comm 21.20 Concrete floors.

(1) When concrete floors are provided, the thickness of the concrete shall measure at least 3 inches.

(2) When a concrete floor is placed in clay soils, a 4-inch thick base course shall be placed in the subgrade consisting of clean graded sand, gravel or crushed stone.

(3) When a concrete floor is placed on sand or gravel soils, the base course may be omitted unless drain tile is installed. If drain tile is installed, the requirements of s. Comm 21.17 shall be met.

Comm 21.203 Garage floors.

(1) MATERIALS. Garage floors shall be constructed of concrete or other noncombustible materials which are impermeable to petroleum products. Slab-on-grade concrete garage floors shall be at least 4 inches thick and placed over at least 4 inches of granular fill.

Note: It is not the intent of sub. (1) to require a concrete floor to be sealed to make it completely impermeable.

(2) CONFIGURATION. The floor shall be sloped such that water is removed in accordance with one of the following:

(a) Water drains toward the overhead door or to exterior grade such that no damage will be caused to any structural member or wall covering of the garage or the dwelling.

(b) Water drains into an interior floor drain that complies with the requirements of ch. Comm 82.

Note: See s. Comm 82.34, Uniform Plumbing Code, for floor drain requirements.

Question: *Can the garage floor be at the same elevation as the finished floor of the dwelling or is a step or landing required in the garage at a door between the two?*

Answer: *The code doesn't require an elevation change between the garage floor and the dwelling floor, only that the garage floor slope to the main exterior opening or floor drain.*

Question: *What is the minimum pitch of the garage floor?*

Answer: *The code is silent on this and doesn't prescribe the degree of pitch, only that it must have a slope to provide drainage. An suggested rule of thumb for concrete flat work is 1/8 inch drop per foot of run.*

Comm 21.205 Wood floors in contact with the ground.

Wood floors in contact with ground shall comply with the requirements under s. Comm 21.18 (4).

These floors would also have to comply with Comm 21.10 (1), (2), and (3).

Comm 21.21 Precast concrete floors.

Precast concrete floors shall be designed through structural analysis, or load tables furnished by the precast product fabricator may be used, provided the load tables were developed using structural analysis or load testing.

Comm 21.22 Wood frame floors.

Unless designed through structural analysis, wood frame floors shall comply with the following requirements:

(1) FLOOR JOISTS. Wood floor joists shall comply with the requirements of s. Comm 21.02 (3) (a). The minimum live loads shall be determined from s. Comm 21.02. Where sill plates are provided, the sill plates shall be fastened to the foundation. Double floor joists shall be provided underneath all bearing walls which are parallel to the floor joists.

Floor Joist Design

Question: *Does the deflection of floor joists have to be limited to the L/360 as shown in the upper left corner of Table J-1 found in the code appendix.*

Answer: *There is no requirement in ch. Comm 21 stating what the maximum deflection of structural members must be. Deflection would, therefore, be controlled indirectly through accepted engineering practice. Also, there is no rule in Ch. Comm 21 which specifically states that deflection in Table J-1 is part of the rule. All appendix tables are deemed to meet the minimum standards.*

(1m) FLOOR JOISTS ON MASONRY WALLS. (a) On masonry walls, the floor joists shall rest upon one of the following:

1. A mortar-filled or grout-filled core masonry block.
2. A solid-top masonry block.
3. A sill plate at least as wide as the nominal width of the wall.

Note: See s. Comm 21.10 (4) for treatment requirements for wood in contact with masonry.

Floor Joists and Sill Plates

Question: *A wood floor joist system is resting on a sill plate which in turn rests on a hollow concrete masonry foundation. Does the top course of masonry need to have all cores and joints filled with mortar?*

Answer: *Per s. Comm 21.22(1m), the cores of the blocks need not be filled as long as a sill plate is as wide as the block itself is used. If a sill plate is smaller than the width of the block or if a sill plate is not used, then all the cores must be filled.*

(2) FLOOR TRUSSES. Metal plate connected wood floor trusses shall be designed in accordance with the Design Specifications for Metal Plate Connected Parallel Chord Wood Trusses and the National Design Specification for Wood Construction. Truss members shall not be cut, bored or notched.

(3) GIRDERS AND BEAMS. Girders and beams shall be selected from Table 21.22-A1 or Table 21.22-A2 or shall be designed through structural analysis.

(a) Wood girders and beams shall be fitted at the post or column. Adjoining ends shall be fastened to each other to transfer horizontal loads across the joint. Beams shall also be fastened to the posts with framing anchors, angle clips, or equivalent.

(b) Where intermediate beams are used, they shall rest on top of the girders; or shall be supported by ledgers or blocks fastened to the sides of the girders; or they may be supported by approved metal hangers into which the ends of the beams shall be fitted.

TABLE 21.22-A1

MINIMUM SIZES FOR BEAMS AND GIRDERS OF STEEL OR WOOD

Column Spacing	One Floor Only		Roof/Ceiling and One Floor				Roof/Ceiling + One Floor/Ceiling + One Floor			
	Wood Beams ¹ (in., nominal)	A 36 Steel Beams ²	Wood Beams ^{1,3} (in., nominal)		A 36 Steel Beams ²		Wood Beams ^{1,3} (in., nominal)		A 36 Steel Beams ²	
			Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1
24 ft. wide house:										
8 ft.	8x8	---	8x10	10x10	---	---	8x12	10x12	---	---
			6x12	6x12	---	---	6x14	8x14	---	---
10 ft.	8x10	---	8x12	10x12	M 10x9	M 10x9	10x14	10x14	M	M
									12x11.8	12x11.8
12 ft.	8x12	---	6x14	8x14	W 6x12	W 8x10	8x16	8x16	W 8x15	W 8x15
			12x12	10x14	M 12x10	M	14x14	14x14	W 12x16	W 12x16
			10x14	8x16	W	W 8x15	10x16	12x16	W 10x17	W 8x21
					10x11.5					
15 ft.	12x12	---	---	---	W 12x16	W 12x16	---	---	W 12x22	W 14x22
			---	---	W 10x17	W 6x25	---	---	W 8x28	W 8x31
26 ft. wide house:										
8 ft.	6x10	---	10x10	10x10	---	---	10x12	10x12	---	---
			6x12	8x12	---	---	8x14	8x14	---	---
10 ft.	10x10	---	10x12	10x12	M 10x9	M 12x10	10x14	12x14	M	W 12x14
									12x11.8	
12 ft.	8x12	---	8x14	8x14	W 8x10	W 8x13	8x16	8x16	W 8x15	W 8x17
			10x14	10x14	M	M	14x14	12x16	W 12x16	W 10.19
					12x11.8	12x11.8				

			8x16	8x16	W 8x15	W 6x20	12x16	10x18	W 8x21	W 8x24
15 ft.	10x14	---	---	---	W 12x16	W 10x19	---	---	W 14x22	W 14x22
			---	---	W 8x21	W 8x24	---	---	W 8x31	W 8x35
<hr/>										
28 ft. wide house:										
8 ft.	6x10	---	10x10	8x12	---	---	10x12	10x12	---	---
		---	8x12	4x16	---	---	8x14	8x14	---	---
10 ft.	10x10	M 10x7.5	10x12	12x12	M 12x10	W 10x12	12x14	12x14	W 12x14	W 12x14
		W 6x9	8x14	8x14	W 8x13	W 8x13	8x16	10x16	W 8x17	W 10x15
12 ft.	10x12	M 10x9	10x14	12x14	M	W 12x14	12x16	12x16	W 10x19	M 14x18
					12x11.8					
		W 6x12	8x16	10x16	W 8x15	W 8x18	10x18	10x18	W 8x24	W 8x24
15 ft.	10x14	M 12x10	---	---	W 10x19	M 14x18	---	---	W 14x22	W 14x26
		W 8x13	---	---	W 8x24	W 8x24	---	---	W 8x35	W 8x35
<hr/>										

TABLE 21.22-A1

MINIMUM SIZES FOR BEAMS AND GIRDERS OF STEEL OR WOOD

Column Spacing	One Floor Only		Roof/Ceiling and One Floor				Roof/Ceiling + One Floor/Ceiling + One Floor			
	Wood Beams ¹ (in., nominal)	A 36 Steel Beams ²	Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²		Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²	
			Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1
30 ft. wide house:										
8 ft.	8x10	---	10x10	8x12	---	---	10x12	12x12	---	---
			8x12	6x14	---	---	8x14	8x14	---	---
10 ft.	10x10	M 10x7.5	10x12	12x12	M 12x10	M 12x10	12x14	12x14	W 12x14	W 12x14
		W 6x9	8x14	10x14	W 8x13	W 8x13	10x16	10x16	W 10x15	W 10x15
12 ft.	10x12	M 10x9	12x14	12x14	W 12x14	W 12x14	12x16	14x16	M 14x18	M 14x18
		W 6x12	8x16	10x16	W 8x18	W 8x18	10x18	12x18	W 8x24	W 8x24
15 ft.	12x14	M 12x11.8	---	---	M 14x18	W 10x21	---	---	W 14x26	W 14x26
		W 8x15	---	---	W 8x24	W 8x28	---	---	W 8x35	W 10x33
32 ft. wide house:										
8 ft.	8x10		8x12	8x12	---	---	12x12	12x12	---	---
			6x14	6x14	---	---	8x14	10x14	---	---
10 ft.	10x10	M 10x7.5	12x12	12x12	W 10x12	W 10x12	12x14	14x14	W 12x14	W 12x16
		W 6x9	8x14	10x14	W 8x13	W 6x16	10x16	10x16	W 10x15	W 10x17
12 ft.	10x12	M 10x9	12x14	14x14	W 12x14	W 12x14	14x16	14x16	M 14x18	M 12x22
		W 6x12	10x16	10x16	W 10x15	W 10x17	12x18	12x18	W 8x24	W 8x28
15 ft.	12x14	M 12x11.8	---	---	M 14x18	W 12x22	---	---	W 14x26	W 14x26
		W 8x15	---	---	W 8x24	W 8x28	---	---	W 10x33	W 10x33

¹ This table is based upon wood with a fiber bending stress of 1,000 psi. Two acceptable wood beam selections are listed for each loading condition.

² Two acceptable steel beam selections are listed for each loading condition. The first entry is the most economical selection based upon beam weight.

³ Wood main beams or girders may be built up from nominal 2-inch members. The 2-inch members shall be laid on edge and fastened together with a double row of common nails not less than 3 1/2 inches in length. Nails shall be spaced not more than 18 inches apart in each row with the end nails placed 4 inches to 6 inches from the end of each piece. Where built-up beams are employed over a single span, the length of each individual piece used to fabricate the beam shall equal the length of the beam.

TABLE 21.22-A2
MINIMUM SIZES FOR BUILT-UP WOOD BEAMS IN BASEMENTS AND
CRAWLSPACES SUPPORTING ONE FLOOR ONLY

House Width	Fb = 800 psi		Fb = 1000 psi		Fb = 1200 psi		Fb = 1400 psi	
	Col. Spacing ft-in	Beam Size	Col. Spacing ft-in	Beam Size	Col. Spacing ft-in	Beam Size	Col. Spacing ft-in	Beam Size
16 ft.	7-8	3-2x8	8-7	3-2x8	9-4	3-2x8	10-2	3-2x8
	8-11	4-2x8	9-11	4-2x8	10-11	4-2x8	11-10	4-2x8
	9-11	3-2x10	11-1	3-2x10	12-1	3-2x10	13-1	3-2x10
	11-4	4-2x10	12-8	4-2x10	13-1	4-2x10	15-0	4-2x10
	12-0	3-2x12	13-5	3-2x12	14-8	3-2x12	15-10	3-2x12
	13-10	4-2x12	15-7	4-2x12	17-0	4-2x12	18-4	4-2x12
20 ft.	6-11	3-2x8	7-8	3-2x8	8-5	3-2x8	9-1	3-2x8
	7-11	4-2x8	8-11	4-2x8	9-9	4-2x8	10-7	4-2x8
	8-10	3-2x10	9-11	3-2x10	10-10	3-2x10	11-8	3-2x10
	10-2	4-2x10	11-4	4-2x10	12-6	4-2x10	13-6	4-2x10
	10-9	3-2x12	12-0	3-2x12	13-2	3-2x12	14-3	3-2x12
	11-5	4-2x12	13-11	4-2x12	15-2	4-2x12	16-5	4-2x12
24 ft.	6-3	3-2x8	7-1	3-2x8	7-8	3-2x8	8-4	3-2x8
	7-3	4-2x8	8-2	4-2x8	8-11	4-2x8	9-8	4-2x8
	8-1	3-2x10	9-0	3-2x10	9-11	3-2x10	10-8	3-2x10
	9-4	4-2x10	10-4	4-2x10	11-5	4-2x10	12-4	4-2x10
	9-9	3-2x12	10-11	3-2x12	12-0	3-2x12	12-11	3-2x12
	11-3	4-2x12	12-7	4-2x12	13-11	4-2x12	15-0	4-2x12
28 ft.	5-10	3-2x8	6-6	3-2x8	7-2	3-2x8	7-8	3-2x8
	6-8	4-2x8	7-6	4-2x8	8-3	4-2x8	8-11	4-2x8
	7-5	3-2x10	8-4	3-2x10	9-1	3-2x10	9-11	3-2x10
	8-7	4-2x10	9-8	4-2x10	10-6	4-2x10	11-4	4-2x10
	9-0	3-2x12	10-1	3-2x12	11-1	3-2x12	10-11	3-2x12
	10-5	4-2x12	11-8	4-2x12	12-10	4-2x12	13-10	4-2x12
32 ft.	5-4	3-2x8	6-1	3-2x8	6-8	3-2x8	7-3	3-2x8
	6-3	4-2x8	7-1	4-2x8	7-8	4-2x8	8-4	4-2x8
	7-0	3-2x10	7-9	3-2x10	8-7	3-2x10	9-2	3-2x10
	8-1	4-2x10	8-11	4-2x10	9-10	4-2x10	10-8	4-2x10
	8-5	3-2x12	9-6	3-2x12	10-4	3-2x12	11-1	3-2x12
	9-9	4-2x12	11-0	4-2x12	12-0	4-2x12	11-11	4-2x12
36 ft.	5-1	3-2x8	5-9	3-2x8	6-3	3-2x8	6-9	3-2x8
	5-11	4-2x8	6-7	4-2x8	6-9	4-2x8	7-10	4-2x8
	6-6	3-2x10	7-4	3-2x10	8-1	3-2x10	8-8	3-2x10
	7-6	4-2x10	8-6	4-2x10	9-4	4-2x10	10-0	4-2x10
	7-11	3-2x12	8-11	3-2x12	9-9	3-2x12	10-7	3-2x12
	9-2	4-2x12	10-4	4-2x12	11-4	4-2x12	12-4	4-2x12

¹ This table provides maximum allowable spans in feet and inches for main beams or girders which are built-up from nominal 2-inch members.

² Fiber bending stress for various species and grades of wood is given in Appendix A21.

³ The 2-inch members shall be laid on edge and fastened together with a double row of common nails not less than 3 1/2 inches in length. Nails shall be spaced not more than 18 inches apart in each row with the end nails placed 4 inches to 6 inches from the end of each piece.

21.22

⁴ Where built-up wood beams are employed over a single span, the length of each individual piece used to fabricate the beam shall equal the length of the beam.

⁵ Where built-up wood beams are continued over more than one span and where lengths of individual pieces are less than the total length of the complete beam, butt joints shall be located over supports or within 6 inches of the quarter points of the clear span. Where located near the quarter points, the joints in built-up beams shall be separated by at least one lamination and shall not exceed the beam width..

Steel Beams

Question: Please explain the terminology for steel beams in Table 21.22-A1.

Answer: A-36 steel refers to the strength of the steel. It has an allowable tensile yield strength of 36,000 pounds per square inch.

The designations *W* and *M* refer to the standard cross-sectional shapes of steel beams. The term *I* beam is no longer used, but does describe the general shape of these beams. The major differentiating characteristics of a beam are its top and bottom flanges which are horizontal and the vertical web which separates the flanges. The specific descriptions are:

"*W*" - The top and bottom flanges are parallel to each other. Previously called a wide flange beam in some cases.

"*M*" - Cannot be classified as a *W* or *S* shape. Sometimes referred to as a junior *I* beam previously.

It is always best to get the actual shape designation from the suppliers. The two numbers after the shape designation (*W*, *M*) provide (1) the overall depth of the beam section and (2) the weight of the beam itself in pounds per lineal foot.

So a beam designated as a *W* 8 x 15 has a *W* shape with relatively wide flanges, a depth of 8 inches and weighs 15 pounds per lineal foot.

Question: Table 21.22-A1 gives sizes for beams when conventional framing is used. Table 21.22-A2 gives sizes of wood beams when truss roofs are used. Are there any tables that can be used for steel girders and beams when using truss roofs?

Answer: The correct size of a steel beam can be obtained through use of the Steel Construction Manual published by the American Institute of Steel Construction, Inc. This is the same organization that publishes the standard as adopted in s. Comm 20.24(1). This manual contains tables covering different sizes and shapes of steel beams and specifies the maximum load the beam can carry for a certain span. Table A of the following commentary section (21.22(3)) can be used to determine the actual load on the beam. In order to determine the total load on the beam, the actual load on the beam in pounds per lineal inch as calculated by Table A must be multiplied by the number of inches between the supports. The table found in Chapter 2 of the Steel Construction Manual can then be used by selecting a beam and then comparing the actual load on the beam calculated with the maximum allowable load of the beam.

Wood Girder and Beam Design

The beam design tables as given in the Uniform Dwelling Code may be used for the design or analysis of simple span timber beams and headers with uniformly distributed loads.

The structural analysis for simple beams and headers are based on the following formulas:

BENDING

$$M = \frac{w(l)^2}{8}, \quad S = \frac{M}{F_b}$$

HORIZONTAL SHEAR

$$R_v = \frac{w(l)}{2}, \quad F_v = \frac{3(R_v)}{2(b)(d)}$$

$$\text{DEFLECTION} \quad \text{"Delta"} = \frac{5(w)(l)^4}{384(E)(I)} \quad (\text{See Note D})$$

- w = uniform load per length in inches (See Note A)
- l = length of beam between supporting members in inches
- b = width of rectangular member (actual not nominal) in inches
- d = depth of rectangular member (actual not nominal) in inches
- S = section modulus of lumber (See Note B)
- M = bending moment in inch-pounds
- E = modulus of elasticity of lumber (See Note C) in psi
- I = moment of inertia (See Note B) in (inches)⁴
- F = allowable unit stress for extreme fiber (See Note C) in psi
- F_v = allowable unit horizontal shear (See Note C) in psi
- R_v = vertical reaction in pounds
- = deflection in inches

NOTE A - the uniform load per inch on a beam is calculated from the live loads (LL) and dead loads (DL) in pounds per square foot (s. Comm 21.02) and length in inches of supported joists (J). The formula is: $w = \frac{(DL + LL)(J)}{144}$

If more than one level is supported by beam or header, add the loads contributed by each ceiling, floor, and roof system supported to obtain the total uniform load per length on the beam. (See following diagram.)

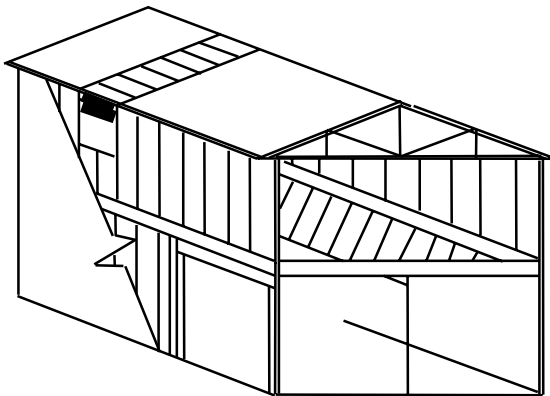
NOTE B - The National Design Specification for Wood Construction, Appendix M gives the value for (S) and (I) for structural lumber. If built up beams and headers are used, the (S) and (I) for each member can be added together if of the same depth for rectangular members:

$$S = \frac{(b)(d)^2}{6} \text{ \& } I = \frac{(b)(d)^3}{12}$$

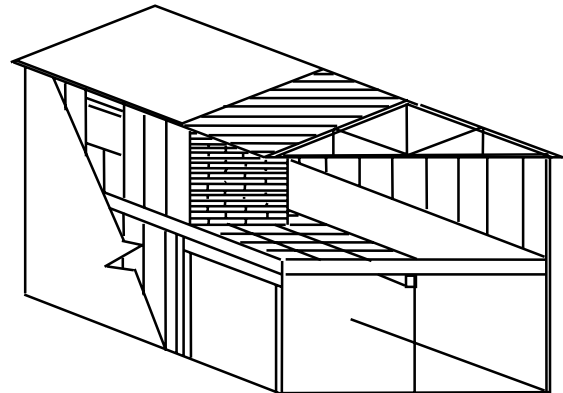
NOTE C - F_b , F_v and E for various wood species can be obtained from Table 4A in the Design Value for Wood Construction Supplement to the National Design Specification for Wood Construction. The values for F_b , F_v & E (allowable) for the wood species must exceed the calculated f_b , f_v & E values (actual).

NOTE D - Deflection "Delta" should be limited to $\frac{(l)}{240}$ to reduce plaster cracking, objectionable springiness, and stresses on mechanical systems.

Tributary Areas



Supported joist length equals $\frac{1}{2}$ the sum of the joist plus $\frac{1}{2}$ the required bearing area called for in the code or truss spans on both sides of beam or header



When the beam or header supports more than one structural system, the loads of each system are added.

The following two tables may be used to size beams or headers. Table A provides the actual loads per inch on the member for various loading situations.

TABLE A Designed to give load (w) on a beam or header for various roof, ceiling and floor systems in pounds per lineal inch. Includes dead and live loads. If multiple loads are supported by the beam or header, then add the loads together from the applicable columns.

Supported Member Length in Feet*	(w)** Roof Zone 1	(w)** Roof Zone 2	(w) Ceiling Truss No Storage	(w) Ceiling Joist No Storage	(w) Ceiling Joist With Storage	(w) Floor: Per System
4	15	13	3	7	10	17
5	19	15	4	9	13	21
6	22	18	5	10	15	25
7	26	21	6	12	18	30
8	31	25	7	14	21	35
9	34	27	8	16	24	39
10	38	30	9	18	26	43
11	41	34	10	19	29	47
12	44	37	11	21	31	51
13	49	40	12	23	33	56
14	53	42	13	24	37	60
15	56	45	14	26	39	64
16	60	48	15	28	42	69
17	64	51	16	29	44	73
18	66	53	17	31	46	76

*See previous page for diagrams. Note that you may need to use different lines of this table for a beam or header that supports multiple systems of different supported member length.

**When there is a roof overhang, its length must be added to the supported member length.

ACTUAL LOAD ON BEAM OR HEADER = ROOF (w) + CEILING (w) + FLOOR (w)

(4) BEARING AND END CONFIGURATION. (a) Sawn lumber. 1. 'Joists.' Wood joists made of sawn lumber shall meet the following bearing requirements:

a. Wood joists supported on wood or metal shall have a bearing surface of at least 1 1/2 inches measured from the end of the joist.

b. Wood joists supported on masonry or concrete shall have a bearing surface of at least 3 inches measured from the end of the joist.

c. The tail end of a floor joist may not extend past the edge of a beam by more than the depth of the floor joist.

d. Wood floor joists with ends that intersect over a beam shall have the ends overlap at least 3 inches and be securely fastened together with at least two 12d common nails or the ends shall be butt-jointed or face-jointed and fastened with ties, straps, plates or solid blocking.

2. 'Beams and girders.' Beams and girders made of sawn lumber shall have a bearing surface on their supports of at least 3 linear inches parallel to the beam or girder and be at least as wide as the beam or girder.

(b) Engineered wood products. Bearing surface for engineered wood products shall be in accordance with the manufacturer's instructions provided those instructions were developed through structural analysis or product testing and are applicable to the configuration.

Floor Joist Tails

Question: *Why can't the tail ends of joists overlap by more than the depth of the floor joist?*

Answer: *The reason for the requirement is to prevent potential subfloor uplift from the tail end reaction to the deflection of the joist span. This could be more of a problem at the center beam of a house in which the clear span roof trusses are used and there is no bearing wall resting on the floor joist tail ends.*

Question: *Can wood shims be used under a steel beam or under a steel column for minor dimensional adjustments? What about pressure treated lumber?*

Answer: *Maybe, but not likely, since the shim material used would need a compressive strength equal to or greater than the loads imposed by the typically highly loaded steel members. If structural calculations are lacking on this point, then steel shims would be required.*

(5) NOTCHING AND BORING. Notching and boring of beams or girders is prohibited unless determined through structural analysis.

(a) Notching of floor joists. 1. Notches located in the top or bottom of floor joists shall not have a depth exceeding $1/6$ the depth of the joist, shall not have a length exceeding $1/3$ the joist depth nor be located in the middle $1/3$ of the span of the joist.

2. Where floor joists are notched on the ends, the notch shall not exceed $1/4$ the depth of the joist. Notches over supports may extend the full bearing width of the support.

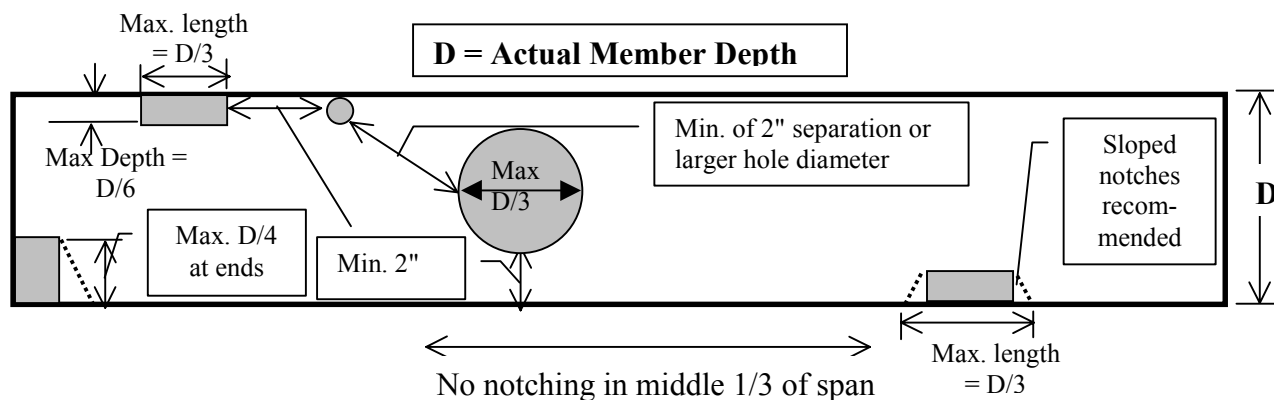
(b) Boring of floor joists. 1. 'General.' A hole may not be bored in a floor joist within 2 inches of a notch or another hole. In no case shall the distance between adjacent holes be less than the diameter of the larger hole.

2. 'Holes near the edge.' Holes bored in the top or bottom 2 inches of a joist shall follow the limitations for notching under par. (a).

3. 'Other holes.' Holes bored in floor joists that are not within 2 inches of the top or bottom of the joist shall have their diameter limited to $1/3$ the depth of the joist.

Holes & Notches in Sawn Joists and Rafters (D = Actual Member Depth)

Member Size	Maximum Hole Diameter or Notch Length = $D/3$	Maximum Edge-Hole Diameter or Notch Depth (except at ends) = $D/6$	Maximum End Notch = $D/4$
2x6	1-3/4"	7/8"	1-3/8"
2x8	2-3/8"	1-1/4"	1-7/8"
2x10	3"	1-1/2"	2-3/8"
2x12	3-3/4"	1-7/8"	2-7/8"



(c) Engineered wood products. Notching or boring of engineered wood products shall be done in accordance with the manufacturer's instructions provided those instructions were developed through structural analysis or product testing.

(6) OVERHANG OF FLOORS. (a) *General.* Except as provided in pars. (b) and (c), a floor joist overhang shall be cantilevered beyond the outer edge of the supporting wall below it by no more than the actual depth of the joist or shall be designed through structural analysis in accordance with s. Comm 21.02 (3).

(b) *Joist overhangs parallel to the main floor framing system.* Joist overhangs that are extensions of, and parallel to, the main floor framing system may extend beyond the depth of the joist without structural analysis provided they meet all of the following conditions:

1. The overhang is cantilevered no more than 2 feet beyond the outer edge of the supporting wall below it.

2. a. The overhang supports a uniform load limited to the weight of the bearing wall and the tributary roof area above it.

b. The tributary length of the roof area, excluding the eave overhang, is no more than 2 feet greater than the actual length of the joist directly below.

c. The eave overhang is no more than 2 feet.

Note: The tributary length is usually half the span of the joist or rafter

3. The joist overhang does not support any concentrated loads. For the purposes of this subsection, a framed opening in the wall with a rough opening of 4 feet or less shall be considered uniform loading.

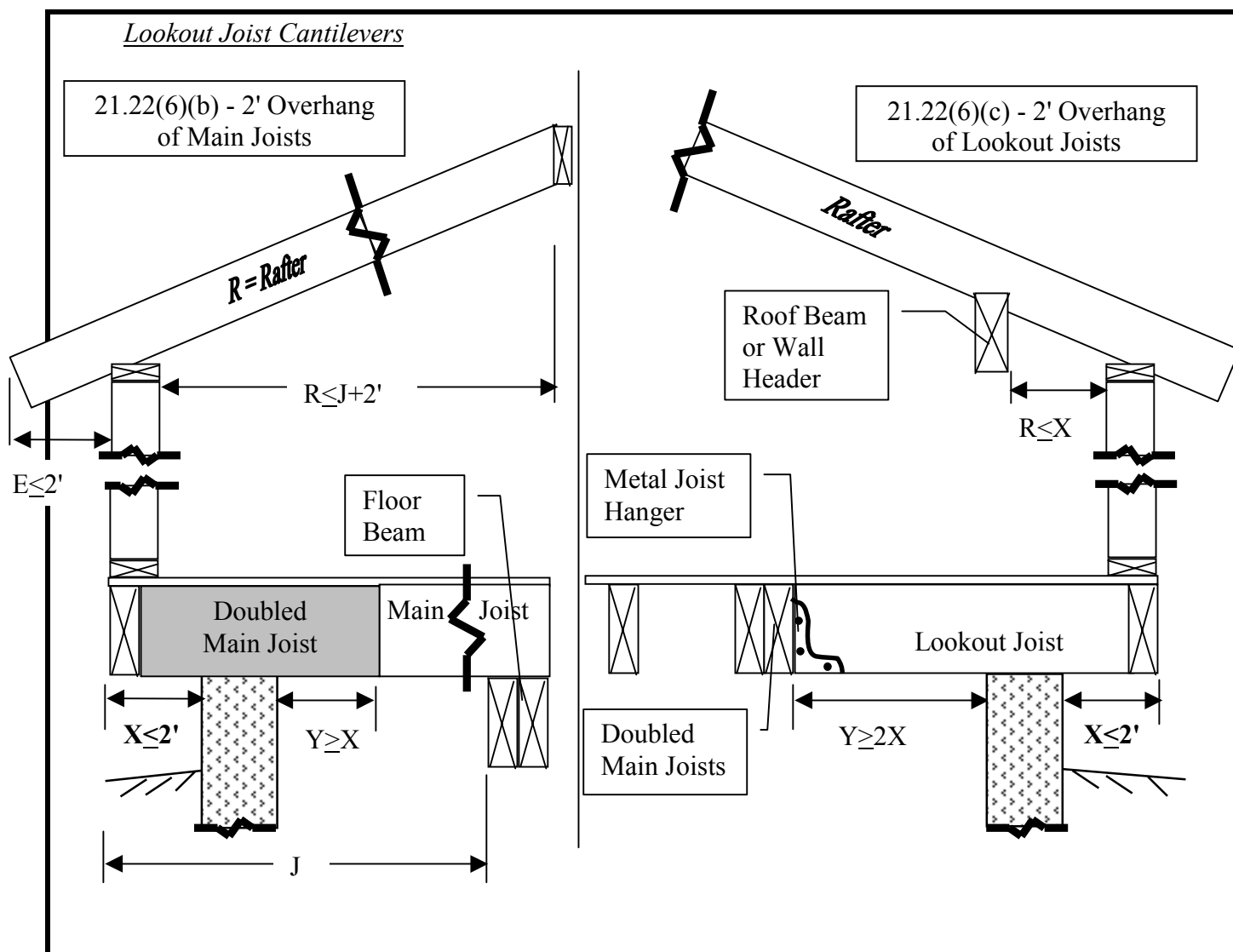
4. a. The cantilevered joist is doubled at the supporting wall.

b. The doubled joist length extends inward beyond the inner edge of the supporting wall by the same distance as the cantilever.

c. The added joist member is secured to the main joist as stated in the nailing schedule in the appendix, under the heading for "floor framing, built-up girder and beams, top loaded".

(c) *Joist overhangs perpendicular to the main floor framing system.* Joist overhangs that are perpendicular to the main floor framing system, or lookout joists, may extend beyond the depth of the joist without structural analysis provided they meet all of the following conditions:

1. The joist overhang is cantilevered no more than 2 feet beyond the outer edge of the supporting wall below it.
2. a. A double floor joist is used to support the lookout joist.
 - b. The double floor joist is located a distance of at least 2 times the cantilever length inward from the outer edge of the supporting wall below.
 - c. The lookout joists are fastened to the double joist with metal hangers.
3. The joist overhang supports no more than either a non-bearing wall or a wall that supports only a roof which spans no more than the floor overhang cantilever length plus the eave overhang.
 - (d) All overhangs longer than the depth of the supporting joist that do not meet all of the conditions under pars. (b) or (c) shall be designed through structural analysis.



Deck Cantilevers

Question: *This section allows a 2-foot cantilever that supports the wall and roof above without the need for calculations. Again, without project specific calculations being required, how far may a deck be cantilevered when it only supports its own floor load?*

Answer: *In the case of the code allowed 2-foot cantilever, the floor assembly is supporting its own known uniform floor load and a point load from the roof system of an unknown span. Therefore it is very conservative. In the proposed case of a cantilevered deck supporting only its own floor load, the loads are all known, therefore a more liberal treatment is possible. So theoretically, the cantilever could be one-half of the simple beam span. This would also parallel the requirement of s. Comm 21.22(6)(b) that the cantilever be anchored back two times the overhang. However, the owner may be unhappy with the deflection at the end of the deck, since for a given span, the deflection for a cantilever is about ten times that of a simple span.*

Besides the above analysis, the designer should evaluate the need for any uplift restraint on the backspan at the most critical loading where the cantilever has full live plus dead loads, while the backspan is under dead load only.

The deflection, non-uniform loading and uplift concerns, should be addressed by the designer. Also, the designer must confirm the assumption that the backspan joist is adequate for the simple span loading case before using the above formula to determine the cantilever length.

(7) FLOOR OPENINGS. Trimmers and headers shall be doubled when the span of the header exceeds 4 feet. Headers which span more than 6 feet shall have the ends supported by joist hangers or framing anchors, unless the ends are supported on a partition or beam. Tail joists (joists which frame into headers) more than 8 feet long shall be supported on metal framing anchors or on ledger strips of at least 2 inches by 2 inches nominal.

Joists Bearing Over Window Openings

In the absence of a wall header, the requirements of this section apply to floor joists that end above a window or other wall opening. This is typically the case for basement windows. Therefore, either framing anchors or a ledge strip, including a sill plate, is required for proper bearing for any joists over 8 feet long.

(8) FLOOR SHEATHING, BOARDS AND PLANKS. (a) Plywood sheathing. Plywood sheathing used for floors shall be limited to the allowable loads and spans shown in Table 21.22-B.

(b) Plywood underlayment. Plywood underlayment shall be installed in accordance with Table 21.22-C.

(c) Combination subfloor - underlayment. Combination subfloor - underlayment shall be installed in accordance with Table 21.22-D.

(d) Floor boards. Where wood boards are used for floor sheathing, the boards shall comply with the minimum thicknesses shown in Table 21.22-E.

(e) Planks. Planks shall be tongue and groove or splined and at least 2 inches, nominal, in thickness. Planks shall terminate over beams unless the joints are end matched. The planks shall be laid so that no continuous line of joints will occur except at points of support. Planks shall be nailed to each beam.

(9) BRIDGING. (a) Sawn lumber. Bridging shall be provided for sawn lumber framing at intervals not exceeding 8 feet where the nominal depth to thickness ratio is greater than 4 to 1.

(b) Engineered products. Bridging shall be provided for engineered framing products in accordance with the manufacturer's recommendations.

TABLE 21.22-B

ALLOWABLE SPANS FOR PLYWOOD FLOOR SHEATHING
CONTINUOUS OVER TWO OR MORE SPANS AND
FACE GRAIN PERPENDICULAR TO SUPPORTS¹

Span Rating ²	Plywood Thickness (in inches)	Maximum Span ³ (in inches)
32/16	15/32, 1/2, 5/8	16 ⁵
40/20	19/32, 5/8, 3/4, 7/8	20 ^{4,5}
48/24	23/32, 3/4, 7/8	24

¹ These values apply to C-D, C-C, and Structural I and II grades only. Spans shall be limited to values shown because of possible effect of concentrated loads.

² Span Rating appears on all panels in the construction grades listed in footnote 1.

³ Plywood edges shall have approved tongue and groove joints or shall be supported with blocking, unless 1/4-inch minimum thickness underlayment or 1-1/2 inches of approved cellular or lightweight concrete is installed or finished floor is 25/32-inch wood strip. Allowable uniform load based on deflection of 1/360 of span is 165 pounds per square foot.

⁴ For joists spaced 24 inches on center, plywood sheathing with Span Rating 40/20 or greater can be used for subfloors when supporting 1-1/2 inches lightweight concrete.

⁵ May be 24 inches if 25/32-inch wood strip flooring is installed at right angles to joists.

TABLE 21.22-C

MINIMUM THICKNESS FOR PLYWOOD UNDERLAYMENT

Plywood Grades and Species Group	Application ¹	Minimum Plywood Thickness (inches)
Groups 1, 2, 3, 4, 5 APA UNDERLAYMENT INT (with interior or exterior glue) APA UNDERLAYMENT EXT APA C-C Plugged EXT	Over smooth subfloor	1/4
	Over lumber subfloor or other uneven surfaces	11/32
Same grades as above but Group 1 only	Over lumber floor up to 4" wide. Face grain must be perpendicular to boards	1/4
APA UNDERLAYMENT Sanded Exterior Grade	Over 16" joist spacing 19/32 subfloor, under tile with organic adhesive	11/32
	Over 16" joist spacing 19/32 subfloor, under tile with epoxy mortar	15/32 ²

¹ Place face grain across supports and end joints over framing.

² Leave 1/4" space at panel ends and edges, trim panels as necessary to maintain end spacing and panel support on framing. Fill joints with epoxy mortar. With single layer floors, use solid lumber backing or framing under all panel and edge joints, including T & G joints.

TABLE 21.22-D

MINIMUM THICKNESS FOR PLYWOOD COMBINATION SUBFLOOR- UNDERLAYMENT. PLYWOOD CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PERPENDICULAR TO SUPPORTS^{1,2}

Plywood Grade	Plywood Species Group	Maximum Support Spacing ³		
		16" o.c. Panel Thickness (inches)	20" o.c. Panel Thickness (inches)	24" o.c. Panel Thickness (inches)
Sanded exterior type	1	1/2	5/8	3/4
	2 and 3	5/8	3/4	7/8
	4	3/4	7/8	1
Underlayment C-C Plugged Sturd-I-Floor ⁴	All Groups	APA Rated Sheathing and APA Rated Sturd-I-Floor shall be installed consistent with their rating.		

- ¹ Spans shall be limited to values shown, based on possible effect of concentrated loads.
- ² Unsupported edges shall be tongue and groove or blocked except where 1/4-inch underlayment or 25/32-inch finish floor is used.
- ³ Underlayment, C-C Plugged, sanded exterior type: allowable uniform load based on deflection of L/360 span for spans 24 inches or less is 125 psf; and for spans 48 inches, 65 psf.
- ⁴ The department will accept subfloor underlayment panels such as Sturd-I-Floor which meet the requirements of APA manufacturing specifications for Sturd-I-Floor panels.

TABLE 21.22-E
MINIMUM THICKNESS OF FLOOR BOARDS

Joint Spacing (inches)	Minimum Net Thickness (inches)	
	Perpendicular to Joist	Diagonal to Joist
24	11/16	3/4
16	5/8	5/8

Comm 21.225 Decks.

Decks attached to dwellings and detached decks which serve an exit shall comply with the applicable provisions of this chapter, including but not limited to:

- (1) Excavation requirements of s. Comm 21.14;
- (2) Footing requirements of s. Comm 21.15 (1) (f);
- (3) Frost penetration requirements of s. Comm 21.16;
- (4) Load requirements of s. Comm 21.02;
- (5) Stair, handrail and guardrail requirements of s. Comm 21.04; and
- (6) Decay protection requirements of s. Comm 21.10.

Subchapter VII — Walls

Comm 21.23 Wall design.

(1) **LIVE AND DEAD LOADS.** All walls shall support all superimposed vertical dead loads and live loads from floors and roofs.

(2) **HORIZONTAL WIND LOAD.** Walls shall be designed to withstand a horizontal wind pressure of at least 20 pounds per square foot applied to the vertical projection of that portion of the dwelling above grade. No wind load reduction shall be permitted for the shielding effect of other buildings.

Comm 21.24 Exterior covering.

(1) **GENERAL.** The exterior walls shall be covered with a permanent weather resistant finish.

(2) **DURING CONSTRUCTION.** During construction, wall cavity insulation may not be installed until a water-resistant exterior covering is in place over the wall cavity.

Note: An example of acceptable water-resistant covering is foam sheathing with taped joints and the permanent doors and windows installed.

(3) **FLASHING.** (a) Corrosion-resistant flashing shall be installed in the exterior wall to prevent water from entering the wall cavity or coming in contact with the structural framing components.

(b) The flashing shall extend to the surface of the exterior wall finish and prevent water from reentering the exterior wall.

(c) Flashing shall be provided at all of the following locations:

1. At the top of all exterior door and window openings, unless using self-flashing windows that provide at least one inch of flashing around the opening, including the corners.
2. At the intersection of chimneys or other masonry construction with frame walls.
3. Under and at the ends of masonry, wood or metal copings and sills.
4. Continuously above all projecting wood trim.
5. Where porches, decks or stairs attach to a wall or floor assembly of wood frame construction.
6. At wall and roof intersections.
7. At built-in gutters.

Exterior Covering

Question: *When is it necessary to have building paper or some other moisture resistant membrane under the exterior siding or other covering?*

Answer: *Building paper or a similar product is required if the exterior finish material or the underlying material does not provide the required continuous moisture-*

resistant covering. The department accepts the following as meeting this requirement:

- *Exterior-rated panelized siding with joints caulked, lapped, flashed or battened.*
- *Any moisture-resistant covering applied over building sheathing panels such as plywood, foamboard or fiberboard.*

The department does not accept the following exterior covering unless applied over building paper or the equivalent:

- *Lap siding applied directly to studs (no sheathing).*
- *Wood shakes or shingles.*

However, if the manufacturer's/supplier's installation requirements for the chosen finish material direct the use of building paper, then that would be the controlling requirement.

Question: *Must the siding or finished surface material be in place before insulation can be installed?*

Answer: *No, so long as it is "protected" from the elements which could cause excessive moisture in the finished walls. This "protection" could be any of the materials above.*

Comm 21.25 Wood frame walls.

Unless designed through structural analysis, wood frame walls shall comply with the following requirements.

(1) **STUD CONFIGURATION AND BRACING.** (a) **Studs.** Wood studs shall comply with the size and spacing requirements indicated in Table 21.25-A. Studs in the exterior walls shall be placed with the wide faces perpendicular to the plane of the wall.

TABLE 21.25-A

MAXIMUM UNBRACED STUD LENGTH WITH SPACING AND LOADING

Size	Grade	Maximum height (feet)	Spacing (inches)			
			Supportin g roof and ceiling only	Supporting one floor, roof and ceiling	Supporting two floors, roof and ceiling	Interior and nonload-bearing
2x3	Standard & better	8	16	N/P	N/P	24
2x4 or larger	Utility	8	24	16	12	24